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STUDY OF RADIOACTIVE MINERAL DEPOSITS IN POÇOS DE CALDAS
BY LANDSAT IMAGERY

Raimundo Almeida Filho
Waldir Renato Paradella

The Poços de Caldas alkaline massif concentrates the largest uranium deposits in Brazil and represents, from the geological point of view, a reasonably studied area.

Visual and automatic interpretation of multispectral LANDSAT images permitted the disclosure of new and important controls of the radioactive deposits (Uranium and Thorium) in the region.

It was verified that the known radioactive anomalies and mineral occurrences are located mainly around secondary circular structures associated with the development of caldera (Figs. 1 and 2). These internal circular structures and the associated faults provided favorable zones of weakness through which the mineral solutions were percolated. The interpretation results agree with available geological, altimetric and geophysical data.

The identification of several other circular structures, inside the main caldera, is highly suggestive as a guide for the prospection of new deposits in the area and in other similar complexes.

Fig. 1 - The Poços de Caldas Alkaline Massif and the internal circular structures enhanced by contrast stretch (Image-100).

Fig. 2 - The internal secondary structures of the Poços de Caldas Complex enhanced by the Image-100, using vegetation as training areas (yellow).

AUTOMATIC INTERPRETATION OF LANDSAT MULTISPECTRAL DATA
FOR THE PROSPECTION OF CLAY DEPOSITS

Raimundo Almeida Filho
Waldir Renato Paradelia

This work was carried out with the objective to test the applicability of automatic interpretation of LANDSAT MSS data for location of new deposits suitable for use in the ceramic industry.

LANDSAT MSS computer compatible tapes were analyzed in the Image-100 multispectral analyzer. The Poços de Caldas area, where important clay deposits are known to occur, was selected as a training area. Spectral characteristics were obtained by single and multi-cell signature acquisition techniques. The results obtained for the Poços de Caldas area are displayed in figure 1, where the yellow color corresponds to the clay deposits of economic interest.

The spectral signatures obtained for the Poços de Caldas area were applied to the Rio Claro - Pindaíba - São Pedro area, where the geological setting is favourable for the occurrence of similar deposits. Figure 2 shows the results obtained where the yellow spots along the drainage lines corresponds to clay occurrences confirmed by later field checks.

The results obtained are very suggestive for the use of LANDSAT data for prospecting of industrial minerals and rocks.

Fig. 1 - Poços de Caldas Alkaline Complex. Yellow color indicates areas of clay occurrences. Approximate scale 1:250,000.

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Fig. 2 - Rio Claro-Pindaíba-São Pedro region. The small yellow spots along the main drainage lines indicate potential areas for the prospection of clay occurrences. Approximate scale 1:100,000.

APPLICATION OF LANDSAT IMAGERY TO REGIONAL GEOLOGICAL MAPPING OF THE BRAZILIAN AMAZON REGION

Gilberto Amaral *

As an attempt to establish a scheme for the geological development of the shield areas within the Brazilian portion of the Amazon region, the author has carried out the interpretation of 80 LANDSAT scenes and 120 mosaics of radar imagery. Ground truth was provided by literature analysis and field work in test areas. As a result, a map at the 1:5,000,000 scale was produced, covering an area of about 4 million sq. km. This map, shown in figure 1, presents the main geologic units and their structures. With this map, and near 300 geochronological determinations, it was possible to determine the sequence of events that affected the region during the Precambrian. Iron and manganese bearing metasedimentary rocks were easily mapped. An important episode of acidic to intermediate volcanism was identified and mapped. It is considered the largest known volcanic event of this type that occurred during the Precambrian. It is associated with several occurrences of tin, wolframium, niobium, gold, copper, lead, zinc and molybdenum, being the economically most important unit of the region. Tin bearing granites and nickel and chromium bearing ultrabasic rocks were also identified. Flat lying Precambrian sedimentary sequences were easily mapped which are associated with high grade manganese deposits.

Three months of work were necessary for the analysis of the imagery and preparation of the final map. This map, with the respective report, has been used, since 1974, as a reference frame for other detailed geological work being done on the region.

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Fig. 1 - main geologic units and their structures.

AUTOMATIC INTERPRETATION OF LANDSAT IMAGERY FOR PROSPECTION OF MINERAL DEPOSITS IN THE AMAZON REGION

Gilberto Amaral *

The purpose of this project is to evaluate the potentialities of LANDSAT imagery for the location of new mineral deposits in the densely forested portion of the Amazon region. As a first approach, three test sites were selected, all with known mineral deposits. The first one was the Serra dos Carajás area with the largest Brazilian iron deposits (20 billion tons of high grade ore). A very clear association between supergene ore and vegetation is known to occur, and is clearly discernible in photographic images. However, newly deforested areas present the same visual pattern. An attempt was made to use automatic interpretation (Image-100) for discriminating only the ore bearing areas. The results are shown in figure 1, which presents the iron bearing zones in green. The only interferences were observed in parts of the main rivers of the area and can be easily eliminated by visual analysis. The automatic interpretation parameters obtained in this way will be used for prospecting similar deposits in potentially favorable areas in other parts of the region.

The second test site was the Xingu River valley, where tin-bearing alkaline granites are known to occur. These granites are rich in potassium, and soil cover is thinner than other types of granites. This results in clear differences in vegetation cover. Shape of intrusions, tonal differences and morphological aspects are strong aids for visual interpretation. Similar results were obtained by automatic interpretation.

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Fig. 1 - iron bearing zones.

when ratioing of channels 5 and 7 was used, enhancing the contrasts among these granites and other ones.

The third selected area was the Oriximiná region at the Trombetas River valley, where 200 billion tons of bauxite deposits are known to occur. A subtle tonal difference was observed by visual analysis of images of band 7, associated with a characteristic morphology (table mountains). Automatic analysis did not present the same results because large areas of lowlands were interpreted as bauxite bearing areas. A preliminar interpretation of such results is the erosion of bauxite from the table mountains and deposition in the lower portions. This project is being continued with analysis of imagery obtained in different seasons, where the relations among vegetation and ore are better displayed.

The results obtained up to the moment are very encouraging and the project will be continued for manganese and nickel deposits.

GEOLOGY OF RIO DE JANEIRO STATE BY LANDSAT-1 IMAGERY

Liu Chan Chiang

Paulo Roberto Menezes

Rio de Janeiro State is situated in the south-east coastal region of Brazil. The extremely stressed Precambrian complex is distributed in the whole state and is composed of various kinds of gneisses, migmatites and igneous intrusives. In the last two decades, different aspects of geological research and field surveys have been carried out in several specific portions of the state, but because of the difficulty of differentiation of the lithological mapping units and delineation of the regional structural features, only a synoptic view as the one provided by the LANDSAT system allowed the construction of a geological map covering the whole state. The advent of the remote sensing technology, especially the LANDSAT system, made it possible for the mapping of such a broad region in a short period of time, especially under the requirements of economy, be carried out.

The state is covered by eight MSS frames. Only visual interpretation using the bulk images (4 bands) in the scale of 1:500,000 were used. The following features were considered in the interpretation of the images: topography, drainage patterns, distribution and density of vegetal coverage, land use and gray levels (tones).

The Precambrian complex distributed in the state is divided into three large groups named the "Indetermined Precambrian Complex", the "Paraíba do Sul Group" and the "Serra dos Orgãos Group". This division is based mainly on the major topographic differences and is coincident to the existing geochronological studies (Cordani et alii, 1968-1973) and the history of the tectonic events. Except for the "Indetermined Precambrian Complex", the "Paraíba do Sul Group" and the "Serra dos Orgãos Group" are still subdivided into three units. These subdivisions were made by the analysis of the image feature such as topographic varieties, the drainage anomalies, and the contrast of gray levels. Otherwise, marble has been recognized at some places in the state. It is

massive crystalline granular rock composed of calcite grains. The imagery also shows very well the igneous intrusive bodies along the "Serra do Mar" mountain range and the sedimentary accumulations of different depositional environments on the coastal plain and along the coast. All the aerogeologic mapping units were checked in the field and are in agreement with the lithologic differences.

The LANDSAT imagery shows a clear picture of various structural patterns of the numerous lineaments of diverse trends. Along the broad Paraíba do Sul river valley, where the Paraíba do Sul Group is distributed, two principal sets of structural lineaments can be examined. One of them is longitudinal and shows the principal structural trend extending from São Paulo state in a general direction of $N60^{\circ}-70^{\circ}E$ parallel to the river valley. Another set of structural lineaments is transverse, striking diagonally or perpendicularly the longitudinal lineaments. Along the "Serra do Mar" mountain range, where the "Serra dos Orgãos Group" is distributed, the structural lineaments can be grouped into three sets, which trend in directions respectively around $N45^{\circ}W$, $N40^{\circ}E$ and $70^{\circ}-80^{\circ}W$. Some of these lineaments extend into the Paraíba do Sul river valley, intersect and displace those longitudinal lineaments as well as those transverse lineaments. The broad coastal plain region is almost topographically featureless because it is well denuded and covered by various deposits having structures that are concealed and hard to be examined. However, a general linear trend in a direction around $N60^{\circ}-70^{\circ}E$ can also be observed by comparing the bands. In the area of study, numerous fault lines could be inferred by any of the following categories:

- straight or smoothly curved scarps;
- different mapping units contacting with rather straight or smoothly curved scarps;
- different mapping units contacting with straight or smoothly curved lines;
- truncation of mapping units along a line.

From the differentiation of the rock units and the

delineation of the structural lineaments, the occurrence of marble was clarified. The great deposits of marble occur in regions where the Unit PE_b and Unit PE_c of the Paraíba do Sul Group are distributed. These marble deposits form lentils interspaced or inbedded with gneisses, and are parallel to the main structural trends in the Paraíba do Sul river valley.

This work, which included the following phases: analysis and interpretation of the imagery, construction of the preliminary interpretative geological map, study of the existing geological works, field checking, construction of the final geological map and the writing of the report, took only six months, which proves that the LAIDSAT imagery is an effective, economical and practical remote sensing tool for regional geological study.

Fig. 1 - Geological map of Rio de Janeiro State
concentrated by INPE and DRM-RJ.

APPLICATION OF LANDSAT IMAGERY TO REGIONAL GEOLOGICAL
MAPPING - THE BELO HORIZONTE QUADRANGLE

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The Belo Horizonte Quadrangle of the International Chart of the World on the Millionth Scale was selected to test the applicability of LANDSAT imagery for regional geological mapping in a geologically complex area and with abundant available geological information. The first objective was the development of a methodology for regional geological mapping, and the second one was the improvement of the geological knowledge of the area with a better framing of existing problems. The work consisted of interpretation of 12 LANDSAT frames, analysis of nearly 300 literature references and surveying along 12000 km of geological tranverses.

Figure 1 displays the resulting map which can be compared with the most recent map (1976) available for the greatest part of the area (Figure 2). It is obvious that the map obtained by the proposed methodology is much more complete from the lithological and structural point of view. Many of the existing problems, related to stratigraphical setting, correlation among units and geotectonic evolution of the region were clarified. As a by-product of this project, an updating of the cartographic base at the 1:1,000,000 scale was made.

From the geological point of view, the results permitted a review of previous stratigraphical classifications and detailing of some units. The main structural features were clearly identified together with new ones, previously unknown. The amount of information now available imposes several questions as to previously suggested schemes of geological evolution. The boundaries of the main geotectonic units were better

Fig. 1 - Geological map of the Belo Horizonte Quadrangle
constructed by INPE.

Fig. 2 - The most recent map for the greatest part of the Belo
Horizonte Quadrangle.

defined, in particular the Canastra Arch, which is associated with alkalic-ultrabasic magmatism enclosing phosphate, niobium and rare earth deposits and kimberlite pipes.